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Date et al.

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[45] **Date of Patent: Oct. 17, 1995**

[54] **RESIN SEALED TYPE SEMICONDUCTOR DEVICE**

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[73] Assignee: **Mitsubishi Denki Kabushiki Kaisha**, Tokyo, Japan

[21] Appl. No.: **318,447**

[22] Filed: **Oct. 5, 1994**

Related U.S. Application Data

[63] Continuation of Ser. No. 180,344, Jan. 12, 1994, abandoned.

[30] **Foreign Application Priority Data**

Jan. 13, 1993 [JP] Japan 5-4199

[51] **Int. Cl.**[6] **H01L 23/16**

[52] **U.S. Cl.** **257/666**; 257/692; 257/724

[58] **Field of Search** 257/666, 692, 257/528, 530, 724

[56] **References Cited**

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Primary Examiner—William Mintel
Assistant Examiner—Roy Potter
Attorney, Agent, or Firm—Leydig, Voit & Mayer

[57] **ABSTRACT**

A resin sealed semiconductor device includes a current-detecting resistance for detecting current flowing in a semiconductor element that is a metallic resistance having a coefficient of thermal expansion almost equal to that of the lead frame. Compared to a conventional ceramic chip resistance, its coefficient of thermal expansion differs less from that of the lead frame, thereby preventing deterioration caused by heat stress.

2 Claims, 6 Drawing Sheets

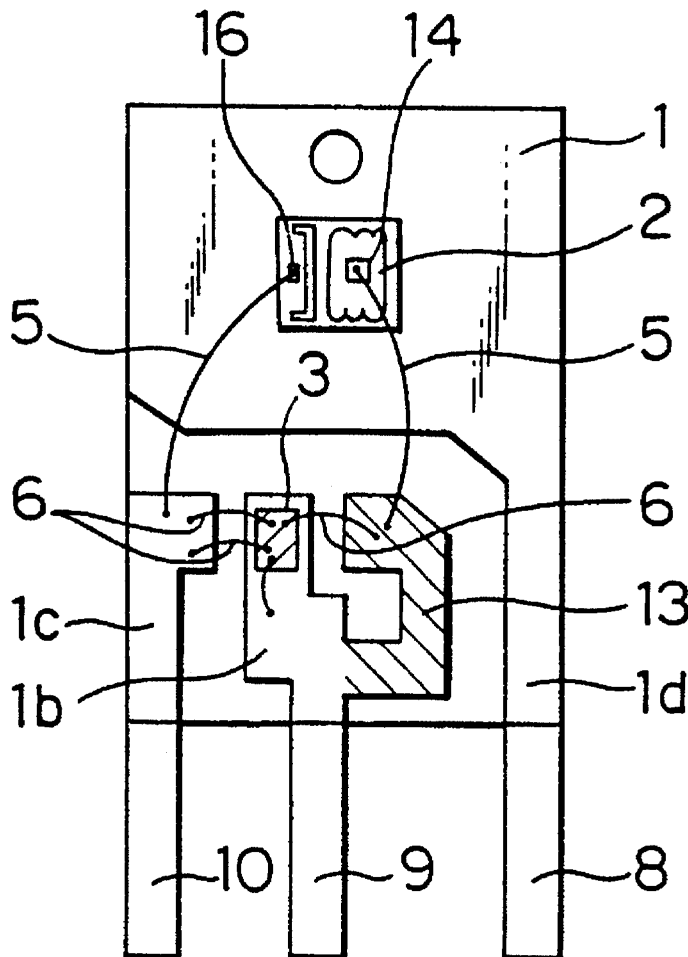

FIG. 1

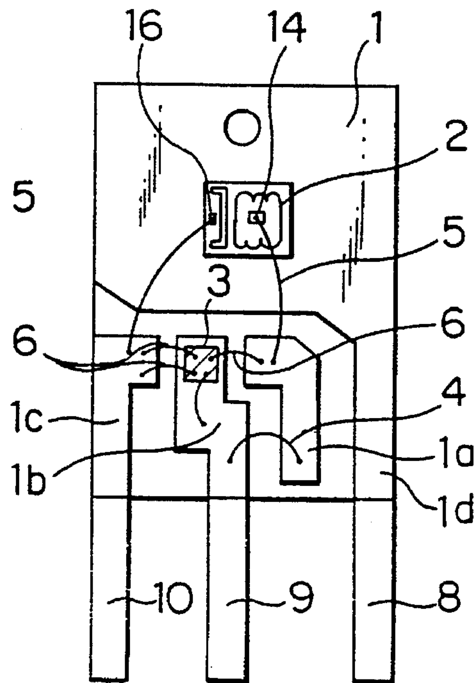

FIG. 2

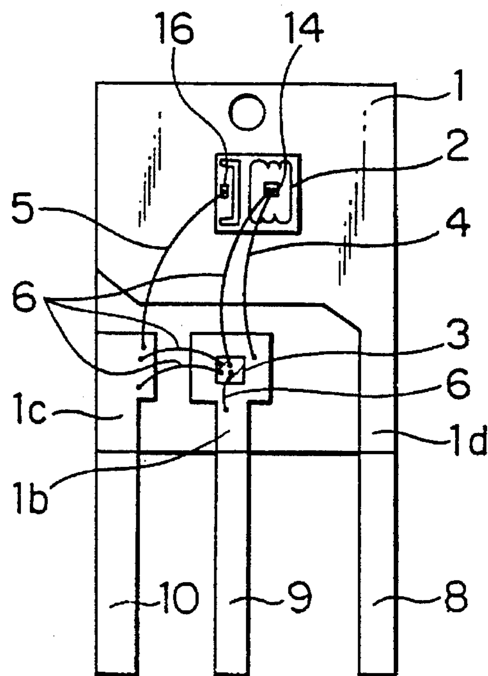

FIG. 3

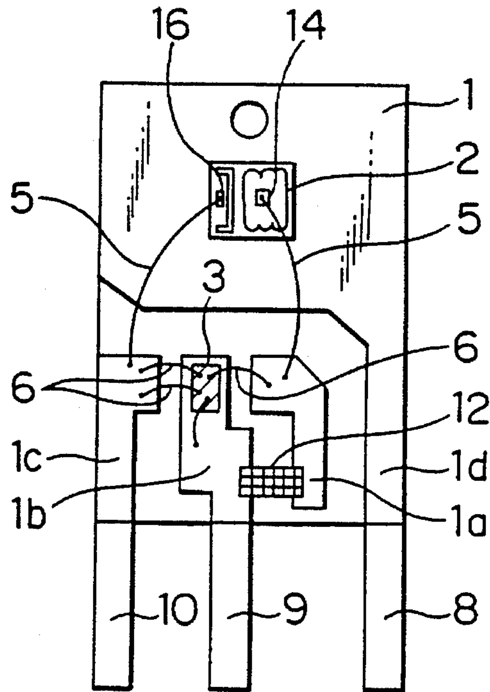

FIG. 4

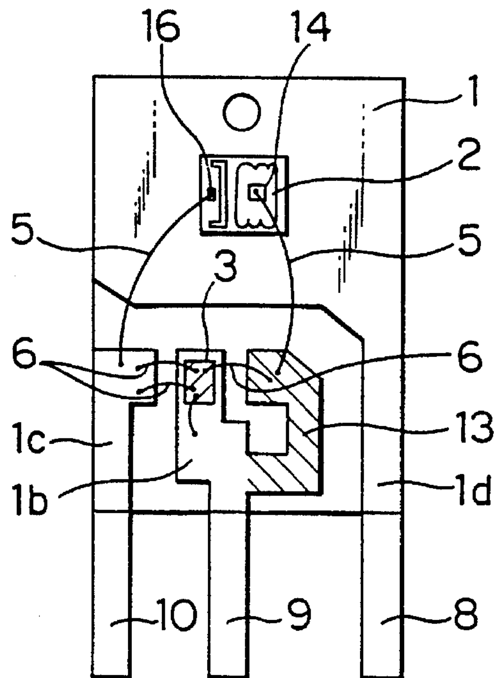

FIG. 5

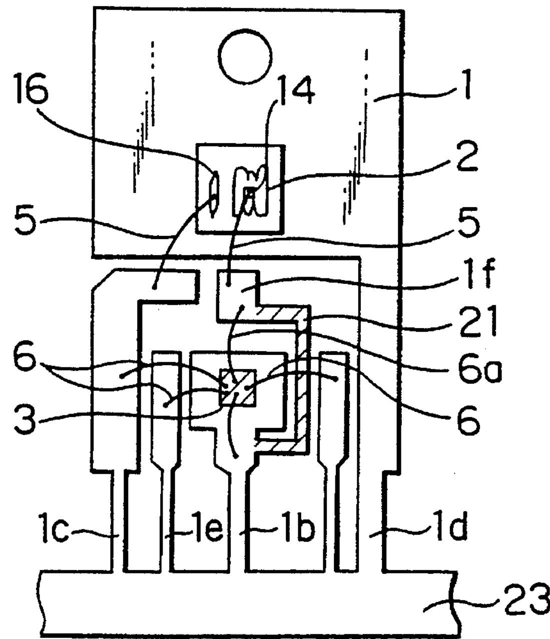

FIG. 6

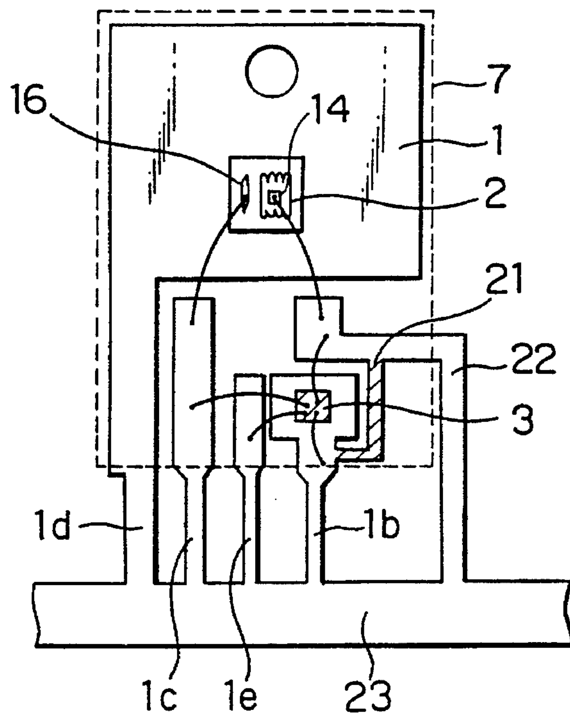

FIG. 7

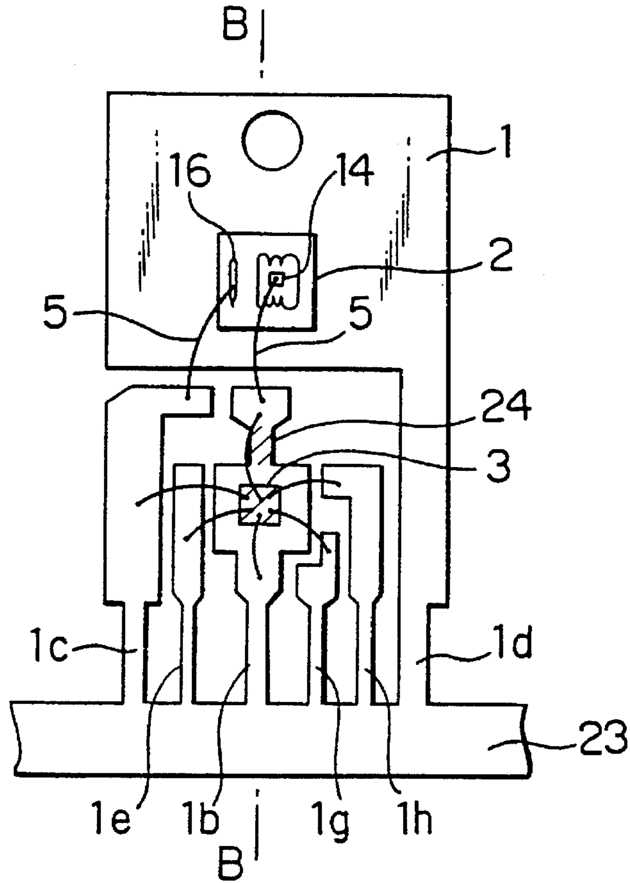

FIG. 8

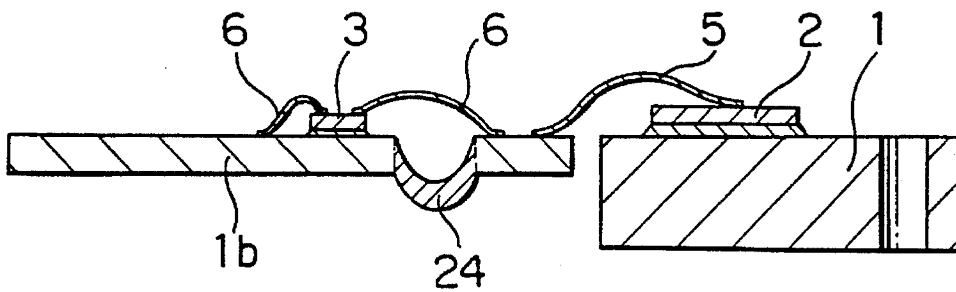

FIG. 9
PRIOR ART

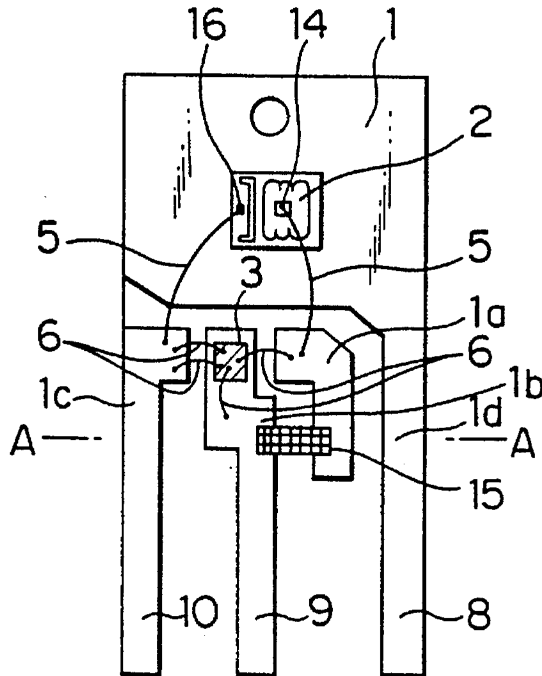

FIG. 10
PRIOR ART

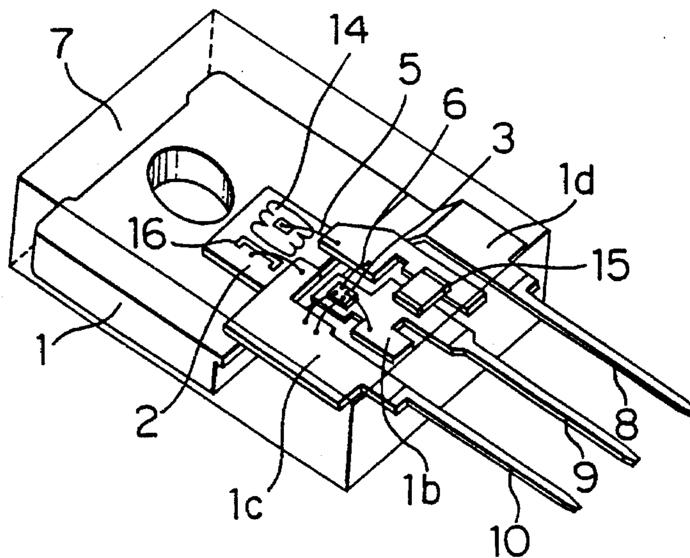

FIG. 11

PRIOR ART

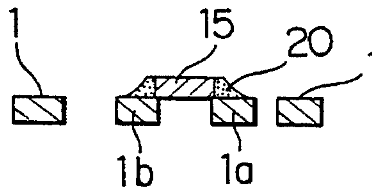

FIG. 12

8
EXTERNAL OUTPUT ELECTRODE
1d
2
10
EXTERNAL INPUT ELECTRODE
1c
5
16
SEMICONDUCTOR ELEMENT
3
6
CONTROLLING INTEGRATED CIRCUIT
5
14
6
15
1b
9
EXTERNAL GROUND ELECTRODE

RESIN SEALED TYPE SEMICONDUCTOR DEVICE

This disclosure is a continuation application of U.S. patent application Ser. No. 08/180,344, filed Jan. 12, 1994, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a resin sealed semiconductor device, more particularly, to a resin sealed semiconductor device used for such devices as lighting system devices for vehicles.

2. Description of the Related Arts

FIG. **9** is a schematic plan view of a conventional resin sealed semiconductor device. FIG. **10** is a transparent perspective diagram thereof. Referring to these figures, onto a lead frame **1** are mounted a semiconductor element and a controlling semiconductor element **3**, which element **3** is an integrated circuit for controlling the semiconductor element **2**. The lead frame **1** is, for example, nickel plated onto a copper base material. In addition, between leads **1***a* and **1***b* is a ceramic chip resistance **15**, which is a current-detecting resistance, fixed by solder **20**, as shown in FIG. **11**. The ceramic chip resistance **15** has, for example, silver, palladium and other conductor electrodes on the surface of an alumina plate. The emitter electrode **14** of the semiconductor element **2**, the controlling semiconductor element **3** and the ceramic chip resistance **15**, are electrically connected by means of the lead **1***a*.

The semiconductor element **2** has its base electrode **16** electrically connected to an external input electrode **10** by means of a lead **1***c*. The front end of leads **1***d*, **1***b*, and **1***c* serve respectively as an external output electrode **8**, an external ground electrode **9**, and an external input electrode **10**, and are connected to an external circuit which is not illustrated. The emitter electrode **14** of the semiconductor element **2** is electrically connected to the lead **1***a* by a thin metallic wire **5** such as an aluminum wire, while the controlling semiconductor element **3** is electrically connected to the leads **1***a*, **1***b*, **1***c*, and the like by thin metallic wires **6** such as gold wire. As illustrated in FIG. **9**, the semiconductor element **2**, the lead frame **1**, and the like are encapsulated with a molded resin **7**, excluding the external output electrode **8**, external ground electrode **9**, and external input electrode **10**. In FIG. **8**, the molded resin **7** is not illustrated.

The conventional resin sealed semiconductor devices have the above-described structure. An equivalent circuit of the resin sealed semiconductor device shown in FIG. **9** is illustrated in FIG. **12**. Referring to the figure, a pulse signal is input from an external circuit (not shown) to the external input electrode, and the semiconductor element **2** is driven. At this time, when the pulse input signal is in a high state, current which flows in the ceramic chip resistance **15** is detected, so that current in excess of a predetermined amount does not flow in the semiconductor **2**. The controlling semiconductor device **3** operates to control the current which flows in the semiconductor element **2** at a constant level.

As described above, in the resin sealed semiconductor device, the ceramic chip resistance **15** has been soldered to the leads **1***a* and **1***b*. This has given rise to problems such as variations in resistance values depending on the amount of solder used, and changes in resistance values caused by fatigue of the solder across the ceramic chip resistance **15** when an endurance test was carried out for a long period of time. There have been additional problems such as large differences in the coefficient of thermal expansion between the ceramic chip resistance **15** and the leads **1***a* and **1***b*, and the apparatus's weakness to heat stress, producing, during operation, deformations which crack the solder. Further, when the ceramic chip resistance **15** had a low resistance, for example 30 mΩ, its precision dropped, reducing yield and increasing costs.

SUMMARY OF THE INVENTION

The present invention intends to solve such problems by providing a highly reliable and inexpensive resin sealed semiconductor device having a current detecting resistance preventing heat stress and having a resistance value that does not change.

According to the invention, there is provided a resin sealed semiconductor device comprising a lead frame, a semiconductor element mounted on a die pad of the lead frame, a controlling semiconductor element for controlling the semiconductor element mounted on the die pad, a current-detecting resistance for detecting current flowing in the semiconductor element mounted on the lead frame; and a sealing resin encapsulating the lead frame, the semiconductor element, the controlling semiconductor element, and the current-detecting resistance, wherein the current-detecting resistance is a metallic chip resistance having a coefficient of thermal expansion almost equal to that of the lead frame.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic plan view of a resin sealed semiconductor device in accordance with a first embodiment of the intention;

FIG. **2** is a schematic plan view of the resin sealed semiconductor device in accordance with a modification of the first embodiment of the invention;

FIG. **3** is a schematic plan view of a resin sealed semiconductor device in accordance with a second embodiment of the invention;

FIG. **4** is a schematic plan view of a resin sealed semiconductor device in accordance with a third embodiment of the invention;

FIG. **5** is a schematic plan view of a resin sealed semiconductor device in accordance with a fourth embodiment of the invention;

FIG. **6** is a schematic plan view of the resin sealed semiconductor device in accordance with a modification of the fourth embodiment of the invention;

FIG. **7** is a schematic plan view of a resin sealed semiconductor device in accordance with a fifth embodiment of the invention;

FIG. **8** is a cross section taken on line B—B of FIG. **7**;

FIG. **9** is a schematic plan view of a conventional resin sealed semiconductor device;

FIG. **10** is a perspective view of the conventional resin sealed type semiconductor device;

FIG. **11** is a sectional view taken along line A—A of FIG. **9**; and

FIG. **12** is a schematic structural view of an equivalent circuit of a resin sealed semiconductor device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiment 1

FIG. **1** is a schematic plan view of a resin sealed semiconductor device in accordance with a first embodiment of the invention. In each of the figures, the same reference numerals designate like or corresponding parts. In FIGS. **1** through **5** and **7** and **8**, the molded resin **7** is not illustrated.

Referring to FIG. **1**, between leads **1***a* and **1***b* is provided as a current-detecting resistance a flexible metallic wire resistance **4**, for example a copper-nickel metallic wire having a coefficient of thermal expansion almost equal to those of leads **1***a* and **1***b*. The wire is connected thereto, for example, by applied pressure. The equivalent circuit of the resin sealed type semiconductor device, illustrated in FIG. **12**, may be applied in the same way to each of the embodiments of the invention. Here, a ceramic chip resistance **15** is replaced by a metallic wire resistance **4**, a metallic chip resistance **12**, a lead frame resistance **13**, and the like.

In the resin sealed semiconductor device having the above-described structure, changes in resistance values caused by the use of solder in the conventional device do not occur because the current-detecting resistance is formed by the metallic wire resistance **4** which is connected by applied pressure. In addition, since the metallic wire resistance **4** has about the same coefficient of thermal expansion as the leads **1***a* and **1***b*, and is flexible, thermal stress caused by differences in the coefficients of thermal expansion of the leads **1***a* and **1***b* with the resistance **4** does not occur. Consequently, deterioration can be prevented, so that a highly reliable and inexpensive resin sealed semiconductor device is obtained.

In the foregoing description, although a copper-nickel metallic wire resistance **4** was used, a copper or iron-nickel metallic wire may also be used in the same way. In addition, although only one metallic wire resistance **4** was used, more than one wire may also be used, or the wire may be wound into a coil for obtaining the desired resistance value.

Further, as shown in FIG. **2**, the metallic wire resistance **4**, which serves as a current-detecting resistance, may be mounted directly between the emitter electrode **14** of the semiconductor element **2** and the external ground electrode **9**, with the same effects obtained as those described above.

Embodiment 2

FIG. **3** is a schematic plan view showing a resin sealed semiconductor device in accordance with a second embodiment of the invention. Referring to the figure, between the leads **1***a* and **1***b* is soldered a copper-nickel metallic chip resistance **12**, which serves as a current-detecting resistance, having about the same coefficient of thermal expansion as the leads **1***a* and **1***b*. Compared to the conventional ceramic chip resistance **15**, there is a smaller difference in the coefficient of thermal expansion between the leads **1***a* and **1***b* and the metallic chip resistance **12**, so that deterioration caused by heat stress can be prevented, providing an inexpensive resin sealed semiconductor device having increased reliability.

In the foregoing description, the metallic chip resistance **12**, formed by a copper-nickel alloy, may be formed by an iron-nickel alloy, with the same effects obtained as those described above.

Embodiment 3

FIG. **4** is a schematic plan view illustrating a resin sealed semiconductor device in accordance with a third embodiment of the invention. In the present embodiment, as a current-detecting resistance a lead frame resistance **13** is formed using a lead, itself, having nickel plated onto a copper base material. The lead frame resistance **13** can be integrally formed by punching the lead frame **1** at the same time as when it is being formed. As a result, the difference in its coefficient of thermal expansion from that of the lead **1***b* disappears, preventing deterioration caused by heat stress from occurring. Consequently, an inexpensive resin sealed semiconductor device with increased reliability is produced. In addition, since the lead frame resistance **13** is formed by pressing and punching, dimensional stability and increased precision in resistance values can be obtained.

In the foregoing description, although the lead frame, itself, having a copper base material plated with nickel was made the lead frame resistance **13**, a lead frame having an iron-nickel base material plated with nickel may also be made the lead frame resistance **13**, with the same effects obtained as those described above.

Embodiment 4

FIG. **5** is a schematic plan view of a resin sealed semiconductor device in accordance with a fourth embodiment of **0** the invention. In the embodiment, a lead frame resistance **21** is provided between the lead **1***b* and an island **1***f*, with the lead frame resistance **21** plated with silver formed in a stripe pattern. By appropriately changing the bonding location of the thin metallic wire **6** on the island, **1***f*, a wide range of resistance values can be selected.

The resistance value of the lead frame resistance **21** must be made, for example about 10 mΩ, so that its width must be made thin enough to allow its resistance to range from 0.1 mm to 0.8 mm. In order not to deform the lead frame resistance **21**, during assembly, an auxiliary lead pin **22** may be provided, as shown in FIG. **6**. The auxiliary lead pin **22**, which protrudes from the side portion of the molded resin **7**, is connected to a tie bar **23** of the lead frame **1**. The auxiliary lead pin **22** is cut at the same time as the tie bar **23** is cut.

Embodiment 5

FIG. **7** is a schematic plan view showing a resin sealed semiconductor device in accordance with a fifth embodiment of the invention. FIG. **8** is a side sectional view taken along line B—B. In the embodiment, the lead frame, itself, is used to form the lead frame resistance **24**, with the lead frame resistance **24** having a curved section. The lead frame resistance **24** may be formed by punching the planar lead frame **1** and then by bending it. Forming a curved section in the lead frame resistance **24** allows the current-detecting resistance to be formed using a smaller area as compared to when it is formed without a curved section, thereby reducing the size of the resin sealed semiconductor device as well as increasing the number of lead pins.

As described above, a highly reliable and inexpensive resin sealed semiconductor device is produced. Deterioration caused by heat stress resulting from a difference in resistance between the metallic chip resistance and the leads can be prevented; changes in resistance values do not occur; and the difference in the coefficient of thermal expansion between the resistance and the lead frame can be absorbed, thereby preventing deterioration caused by heat stress. In addition, since the current-detecting resistance can be formed using a smaller area as compared to when it is formed without a curved section, the resin sealed semiconductor device can be reduced in size, and the number of lead pins increased.

What is claimed is:

1. A resin sealed semiconductor device comprising:

a lead frame including a die pad and leads and having a coefficient of thermal expansion;

a semiconductor element mounted on said die pad;

a controlling semiconductor element for controlling said semiconductor element mounted on said lead frame;

a current-detecting resistance for detecting current flowing in said semiconductor element, said current-detecting resistance being mounted on said leads; and

a sealing resin encapsulating said lead frame, said semiconductor element, said controlling semiconductor element, and said current-detecting resistance wherein said current-detecting resistance portion of a lead of said lead frame.

2. The device of claim 1 wherein said portion of a lead of said lead frame has a concave section.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,459,350

DATED : October 17, 1995

INVENTOR(S) : Date et al.

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 6, Line 5, after "resistance" insert

--comprises a--;

Signed and Sealed this

Fourteenth Day of May, 1996

Attest:

BRUCE LEHMAN

Attesting Officer *Commissioner of Patents and Trademarks*